Foraminiferans from Lake Connewarre, Victoria

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Abstract

A live foraminiferal fauna of eleven species is recorded from Lake Connewarre and the Lower Barwon River. There is no vascular plant growth within the Lake and this together with a high turbity of the waters and varying salinities has limited the foraminiferal fauna. One new species, *Miliammina edens*, is described.

Introduction

About 10 km south of Geelong the Barwon River passes through an extensive reedy swamp area before entering Lake Connewarre - '... as picturesque a sheet of water as ever I beheld' (Lang *in* Campbell 1894). The Lake, which forms part of the Lake Connewarre State Game Reserve (3,300 ha), covers an area of some 1,000 hectares before it is drained by the Lower Barwon River via a winding channel which enters the sea at Barwon Heads (Fig. 1).

The waters of the lake are brackish as it lies within the tidal influence zone, so it is classed as an estuarine lagoon. The salinity varies with the state of the tide and the degree of freshwater input from the Barwon River; it ranges from about 4 parts per thousand near where the Barwon enters, to about 26 ppt near the Lower Barwon exit from the lake (Rosengren 1973). The tidal range is small, probably less than 300 mm but it can be greatly influenced by winds.

The lake is quite shallow - '... a pleasanter and *safer* watercourse can nowhere be found ... the bottom is so near the top' (Campbell 1894). In the early days of settlement yachting regattas were held on the lake until siltation caused the water to become too shallow (Balfour-Melville 1984). Coulson (1935) has shown that the average depth at the present, away from the river channel, is little more than one metre. Sedimentation has deposited over 10 metres of Recent sands and muds on parts of the lake floor, of which about one metre has been deposited since European occupation (Coulson 1935). Although some of this 'European' siltation is due to erosion after land clearance, much came from the sludge and tailings of the Ballarat goldfields where, from about 1856-1887, it is estimated that '80,000,000 cubic yards' of sludge had found its way into the Yarrowee (Leigh) River, and from 1887-1909 '...at least 50,000 cubic yards of sludge and sand per year was entering the river system' (Sludge Abatement Board Reports, *quoted in* Strom 1954). This material has then been reworked down the Yarrowee and Barwon Rivers into Lake Connewarre by normal bed-load flow and by turbulent flow during flood times.

The natural history and geological setting of Lake Connewarre have been dealt with by Coulson (1933, 1935) and Rosengren (1973). Yugovic (1985) has described the vegetation of the area and found that, whilst there was no vascular plant growth in the lake, the reserve supported a very diverse estuarine and freshwater flora. Sherwood (1988) has discussed the possible impacts on Lake Connewarre that may occur with climatic change.

On its northern side the lake is bounded by relatively steep cliffs cut into Middle Tertiary and Pliocene sediments. These cliffs may represent the position of a former coastline during the last interglacial high sea-level when the sea was about 7 m above present levels (Gill and Collins 1983). The southern side of the lake, by contrast, is bounded by flat-lying sands and muds which overlie basalts of Pliocene age and lie only a few metres above sea level. Coulson (1933, 1935) proposed that the lake was formed by basalt flows damming the ancestral Barwon River at Tait Point and Pelican Rocks; the river later cut through the bars and formed an exit to the sea at Barwon Heads.

Coulson (1935) lists foraminiferans (identified by W.J. Parr) obtained from shallow borings made over the lake floor and surrounding areas. These foraminiferans may be either Holocene or Late Pleistocene in age and of the 17 species reported by Coulson all but two are typical of fully marine environments, not the brackish conditions that occur at the present time.

The lake bottom sediment is fine grained, varying from muddy silts to muddy silty sands with a high organic content.

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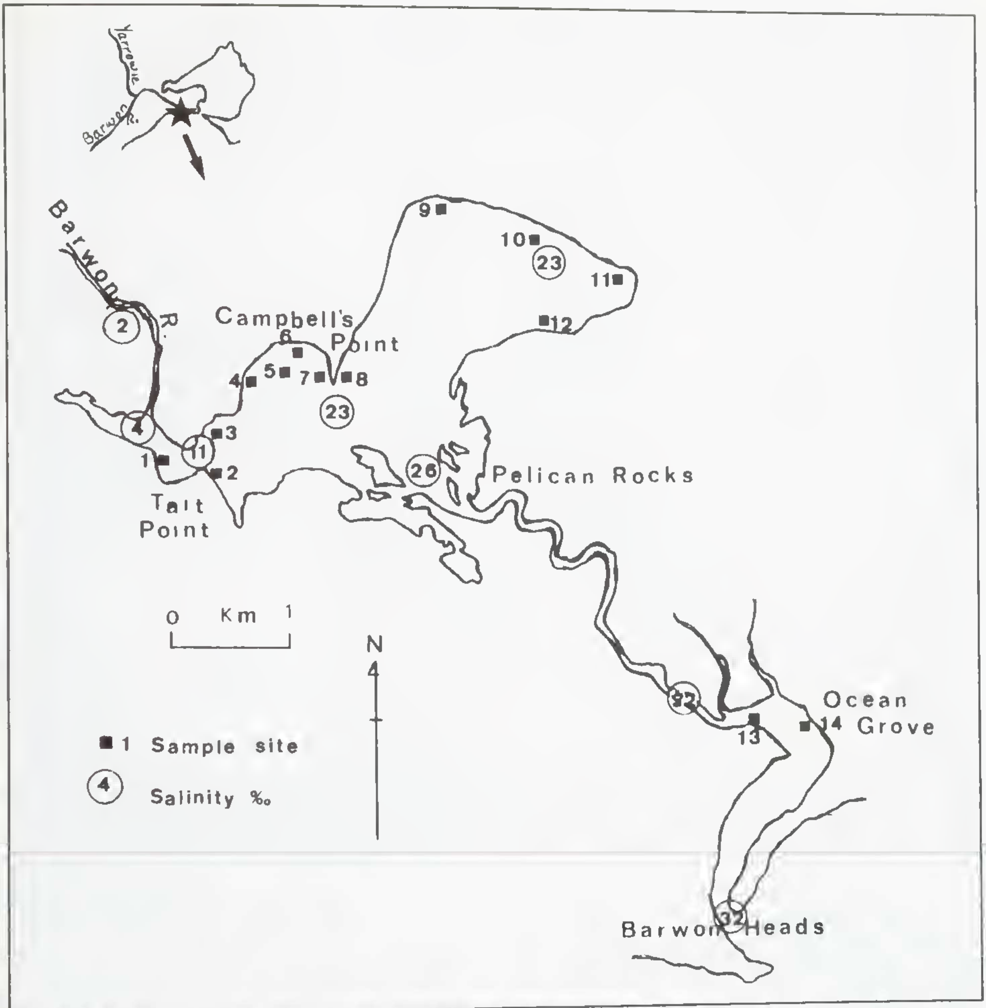

Fig. 1. Lake Connewarre, showing the sample sites and average salinity values (after Rosengren 1973).

Methods

Fifty millilitre samples of sediment were collected, and processed and picked using standard techniques. Rose Bengal was used as a protoplasmic stain to distinguish the living foraminiferans.

Results

A total living fauna of eleven species was found, comprising six agglutinated and five calcareous species. The faunal distribution by sample site is given in Table 1.

The species are well known in Victorian coastal waters and synonymies can be found in Collins (1974).

Ammobaculites barwonensis Collins 1974 (Fig. 2.2).

This species appears to be a very low salinity-tolerant form - it is very common in sample 3 whereas other samples have few, seldom live, specimens. Different salinities appear to affect the growth of this species; in the lower salinities specimens are often flabelliform, while in higher salinities the test becomes more cylindrical.

This species is widespread in Victorian estuaries in lower salinity areas such as the Gippsland Lakes (Apthorpe 1980), Mallacoota Inlet (Bell and Drury 1992) and at Western Port (*pers. obs.*).

Reophax barwonensis Collins 1974 (Fig. 2.1).

This species shows a patchy distribution apparently not related to the salinity. In higher salinity areas (samples 12,14) it grows longer and more robust.

Table 1. Distribution of foraminiferans, Lake Connewarre.
Key: ★- 1 specimen; ■ 2-4 specimens; ● 5-9 specimens; ◆ 10-40 specimens; ⊠ 40+ specimensmens

Samples	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A. barwonensis		◆	◆	■	■	■	●	●	★	◆	◆	■		
R. barwonensis		●	★	■	■	●	★	■			●	■	★	●
W. palustris		●	■		■	●		■		●	■	★	★	
T. inflata			■			●		●	■		●		■	●
M. fusca	◆	◆	◆	●	◆	●	●	◆	◆	●	◆	◆	◆	■
M. edens		◆	◆	●		●	◆	◆		●	●	◆		
Q. seminulum													◆	★
A. aoteanus	◆	◆	●	●	◆	◆	◆	●	●	◆	◆	◆	◆	⊠
E. macellum									■					
E. poeyanum	◆	◆	■	★	★	★		■			■	◆	■	●
H. depressula												★	★	◆

Warrenita palustris (Warren 1957) (Fig. 2.3).

This is a very small, slender species with slightly compressed and overlapping chambers. Rare specimens are found in many samples. This species was originally described from the Holocene marshes of Louisiana; in Victoria it is also found in Swan Bay (*pers. obs.*).

Trochammina inflata (Montagu 1808) (Fig. 2.10).

Apart from rare specimens in sample 6, this species has a patchy distribution confined to the higher salinity waters. It may be substrate controlled since the localities where it is found were those with a higher mud content as was also found by Collins (1974) in Port Phillip Bay, although Matera and Lee (1972) report its preference for coarser sediments in a Long Island salt marsh.

Miliammina fusca (Brady 1870) (Fig. 2.6, 3.4).

This species is typically found in brackish waters. It is large, with a coarse-grained but smoothly finished test surface that is often dark-coloured due to included mineral grains in the test matrix. The chambers are rounded and have a quinqueloculine arrangement. The aperture is rounded with a bar-like tooth on the inner side.

Many of the specimens from the lowest salinity samples (1, 2, 3) showed marked variations in the test growth plan with some specimens even producing a linear tube instead of the norm al chamber.

Miliammina edens n. sp. (Fig. 3.1-3).

Diagnosis: A species of *Miliammina* with a squat, oblong shape and no apertural tooth.

Types: Holotype (Fig. 3.1-2): NMV F74815, Museum of Victoria; from the Recent sediments of Lake Connewarre, Victoria; sample 3.

Paratypes (Fig. 3.3): NMV F74816, Museum of Victoria; from the Recent sediments of Lake Connewarre, Victoria; sample 5.

NMV F74817 Museum of Victoria, (10 unfigured specimens); from the Recent sediments of Lake Connewarre, Victoria, various samples.

Description: Test agglutinate, small; quinqueloculine chamber arrangement; test wall is very fine grained with much cement and a smoothly finished surface; chambers are cylindrical with almost parallel sides, rounded aborally; aperture terminal, rounded to semicircular, without a tooth; a paler rim of much finer grains surrounds the aperture; speci-

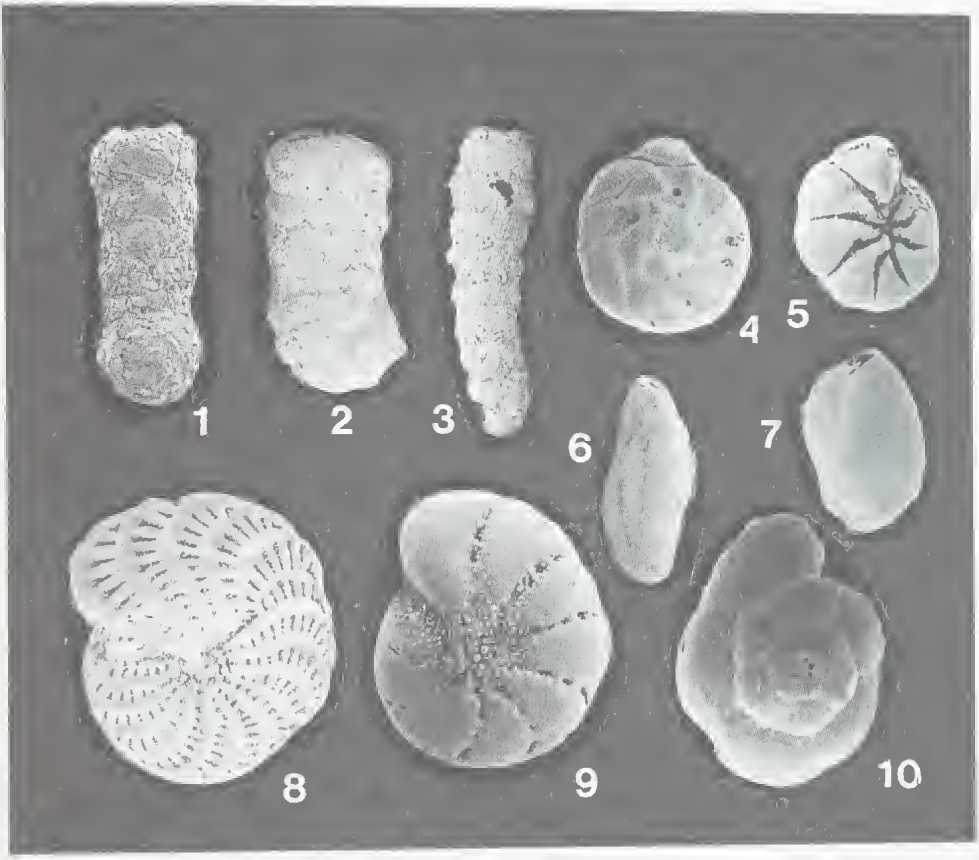

Fig. 2. 1. Reophax barwonensis x 120; 2. Ammobaculites barwonensis x 60; 3. Warrenita palustris x 100; 4. Ammonia aoteanus, spiral side x 60; 5. Ammonia aoteanus, umbilical side x 60; 6. Miliammina fusca x 45; 7. Quinqueloculina seminulum x 75; 8. Elphidium macellum x 60; 9. Haynesina depressula x 120; 10. Trochammina inflata x 60.

mens are usually a pale yellow-fawn colour when alive.

Size: Holotype (Fig. 3.1-2): length=430µm, width=276µm, l/w=1.55.

Paratype (Fig. 3.3): length=380µm, width=288µm, l/w=1.34.

Derivation of name: Lat. e - without; dens - tooth.

Remarks: One of the characteristics of the genus *Miliammina* Heron-Allen and Earland is the presence of a tooth in the aperture (Heron-Allen and Earland 1930). Notwithstanding this, the present species is placed in *Miliammina* partly because there is no other genus available and also because many authors previously have referred to specimens of another species of *Miliammina (M. fusca)* that may or may not have had an apertural tooth e.g. Brodniewicz (1965) both with and without tooth; Saunders (1958) no tooth; and the original description and figure of *fusca* by Brady (1870) with no tooth. Haynes (1973) stated that specimens from Brady's localities contain forms both with and without an apertural tooth; he suggested that the presence or not of a tooth may be a preservational artefact. Of the several hundred specimens of *M. edens* studied none had an apertural tooth. Some specimens of *M edens* become almost spiroloculine in later growth (Fig. 3.3); this is most likely due to age and not salinity ehanges as only a very few larger specimens showed this development.

M. edens differs from *M. fusca* in being of much smaller size; with a squat, oblong shape, having a fine-grained test and never showing an apertural tooth. Although some specimens of *fusca* may not have an apertural tooth (and these were quite uncommon in

Fig. 3. 1-3, *Miliammina edens* n.sp. 1, Holotype, NMV F74815, x120; 2, close-up of aperture of Holotype, x400; 3, Paratype, NMV F74816, x150. 4: *Miliammina fusca*, close-up of aperture, x400. Scale bar: 100 μm for each figure.

Lake Connewarre) the two species can easily be distinguished on their other characters. *M. earlandi* Loeblich and Tappan differs from *M. edens* in having longer and narrower chambers, in having an apertural neck and apertural tooth and is a marine not a brackish, intertidal species.

Quinqueloculina seminulum (Linné 1767) (Fig. 3.7).

This species is only found in the Lower Barwon River downstream of the lake where the waters are almost normal marine (Rosengren 1973; salinities .32 ppt).

Ammonia aoteanus (Finlay 1940) (Fig. 2.4-5).

This is the most common species throughout the lake, although specimens are very rare and fragile in the lowest salinity localities (samples 1, 2, 3).

Elphidium macellum (Linné 1758) (Fig. 2.8).

Small, infrequent specimens are restricted to the more mobile sandy areas where little clay was present.

Elphidium poeyanum (d'Orbigny 1839)

This small, thin walled, lobate *Elphidium* is widespread throughout the lake. However, it is usually only present in rare numbers (1-5 specimens) except in samples 1, 2 and 12 where it is very common (20+ specimens). These sites have widely different salinities and the reason for the larger numbers is not known.

Haynesina depressula (Walker and Jacob 1798) (Fig. 2.9).

This species is common in sample 14, near Ocean Grove, with two isolated specimens found within the lake. This species is found widespread in Victorian shallow water sediments and previously has been recorded under the name *Elphidium simplex* Cushman 1933. It differs from true *E. simplex* in having more defined retral processes and that there is no boss in the umbilical region which, in *depressula*, is covered with small pustules which continue slightly along the sutures. Parr (1945) suggested that this form is a temperate water form of *E. simplex*.

Discussion

Although 11 species of foraminiferans are living in the lake and Lower Barwon River, the absolute number of specimens was low being of the order of 30 specimens in most samples. The reason for these low numbers may be complex. In an estuary the environmental conditions can be subject to large daily and seasonal changes which make it difficult for animals and plants to live. Within Lake Connewarre due to the high turbidity of the water and the possible mobile substrate there is no plant growth (Yujovic 1985; Sherwood 1988). This lack of plant growth within the lake is perhaps the major cause of the lower numbers since it is known that foraminiferan species are more abundant in epiphytic communities in *Enteromorpha, Zostera* beds, (Lee *et al.* 1969; Murray 1973) than in mobile sandy sediments. The turbidity of the water reduces the light intensity and so may affect the production of phytoplankton which is a major food resource for foraminiferans. Decaying plant detritus in the sediments would lead to lower oxygen levels in the substrate and in fine sediments the black sulphide layer (i.e. reduced sediments) lies close to the surface (Gray 1981). Foraminiferans are sensitive to low oxygen levels and are not found living in reduced sediments. However, these factors do not explain all the distribution variations found, although where plant growth was present (samples 2, 3) live foraminiferans were more common (about 100/sample).

Two species, *A. aoteanus* and *M. fusca*, are more tolerant of the changing environmental conditions and were found in all samples. *M. edens* is a hyposaline species found living within the salinity range 11-23 ppt. *Ammobaculites barwonensis* also shows this hyposaline distribution but was most common in the lower salinity samples (2, 3); the high numbers in samples 10 and 11 may indicate lower salinity in that area than given by Rosengren since a small intermittent stream enters near sample 11. In the estuaries of Chesapeake Bay, Virginia, the related species *A. crassus* was found to prefer low salinities and fine, organic-rich substrates, but these were not limiting conditions (Ellison 1972). Sample 9 has quite a depauperate fauna (5 species; 23 specimens); the waters of the northern arm of the lake can be more saline than the sea in summer due to the prevailing SW winds reducing water circulation (Yujovic 1985). With the higher salinity in the Lower Barwon (salinity >32 ppt) *Q. seminulum* and *H. depressula* become important components of the fauna.

To understand the patchiness and variability of the foraminiferan fauna in Lake Connewarre we need much more information on the 'microenvironment' which occurs, especially the physical and chemical factors (such as sediment size, organic content, oxygen level) and the biotic factors (e.g. phytoplankton and microbial production as foraminiferan food resources).

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